

R&D

Carbon Ltd.

USER'S MANUAL

RDC-141 COKE CO₂ REACTIVITY APPARATUS

- IMPORTANT NOTICE -

**This manual contains important instructions regarding the
SAFETY, INSTALLATION, OPERATION AND MAINTENANCE
of this machine which must be
STRICTLY FOLLOWED.**

RDC-141

COKE CO₂ REACTIVITY

APPARATUS

MANUFACTURER'S NOTICE

- (1) This manual should be **CAREFULLY** and **COMPLETELY READ** before attempting to install, operate or maintain this equipment.
- (2) This equipment has been tested in the RDC quality control laboratory and was found to be operating correctly prior to delivery. If for any reason some difficulties are encountered in the installation, operation and/or maintenance of this equipment please contact our Test Apparatus Department at:

R & D Carbon Ltd.
P.O. Box 362
CH-3960 Sierre
SWITZERLAND

Phone : +41 / 27 - 459 29 29
Fax : +41 / 27 - 459 29 25

TABLE OF CONTENTS

Page		
SECTION 1. INTRODUCTION		1
SECTION 2. DESCRIPTION OF APPARATUS		4
2.1	Tube Reactor	5
2.2	Thermocouple	5
2.3	Furnace	6
2.4	Control Box	6
2.5	Temperature Control Unit	7
SECTION 3. SAFETY INSTRUCTIONS		8
3.1	General	9
3.2	Safety Regarding Installation	10
3.3	Safety Regarding Operation	10
3.4	Safety Regarding Maintenance	11
3.5	Warning Labels on the RDC-145 Apparatus	11
SECTION 4. INSTALLATION		12
4.1	Installation Site	13
4.2	Unpacking	14
4.3	Assembly Instructions	14
4.4	Pre-operation Inspection	16
4.5	Calibration	16
SECTION 5. OPERATION		18

RDC-141, User's Manual


5.1	Principle	19
5.2	Sampling and Sample Size	
19		
5.3	Procedure	20
SECTION 6. MAINTENANCE		21
6.1	General	22
6.2	Replacing the Furnace	
22		
6.3	Replacing the Heating Element	
23		
6.4	Replacing the Temperature Controller	
24		
6.5	Replacing the Thermocouple	
24		
6.6	Replacing the External Reactor Tube	
25		
6.7	Replacing the Triac	
25		
6.8	Replacing the Control Unit for Gas & Furnace Control	
26		
6.9	Replacing the Transformer	26
6.10	Periodical Control	
27		
APPENDICES		
28		
Appendix A. Technical Drawings		29
Appendix B. Spare Parts List		31

Section 1.

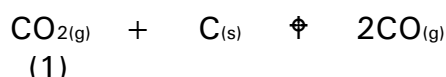
INTRODUCTION

1. INTRODUCTION

The influence of raw materials on the properties of pre-baked anodes can be predicted if correlations between raw material production parameters, raw material properties, anode quality and anode behaviour during electrolysis are known. Such predictions enable the utilisation of good quality, low cost raw materials which can significantly influence aluminium production costs.

Typical prebaked anodes for aluminium production consist of  65% petroleum coke. At constant temperature, different cokes have distinctly different reactivities, the difference being up to an order of magnitude. This can be due to the method of coke manufacture and hence its microstructure, porosity, heat treatment temperature and purity.

Carbon reacts with carbon dioxide according to the endothermic reaction:



This reaction, often referred to as the Boudouard or carboxy reaction, is temperature dependent with the thermodynamically-favoured product being almost all carbon monoxide at temperatures greater than 900 °C (1652 °F). In aluminium production where electrolytic cells operate at 950-960 °C (1742-1760 °F), carbon dioxide, generated at the anode interface by electrochemical oxidation, can attack the carbon anode by such a reaction. This may occur at the interface surface or on the submerged sides beneath the crust as the evolved carbon dioxide sweeps around the anode and is discharged from the cell. Such attack leads to **excess carbon consumption** as the anode is consumed without any metal deposition.

The carboxy reactivity of a calcined petroleum coke can be measured by determining the weight loss of a sample exposed to carbon dioxide at a temperature sufficient to give reaction according to the chemical reaction described in equation 1. This figure allows an assessment of the later carboxy reactivity in the electrolytic cell of anodes made from this coke.

The carboxy reactivity of calcined petroleum coke can be measured using the RDC-141 apparatus described in this manual. A schematic diagram of the apparatus is shown in figure 1.

Figure 1 RDC-141 Coke CO₂ reactivity apparatus
(dimensions in millimeters ; 25,4 mm = 1")

Section 2.

DESCRIPTION OF APPARATUS

2. DESCRIPTION OF APPARATUS

The RDC-141 apparatus consists of a tube reactor, a furnace, a temperature controller and a microprocessor for controlling the gas and furnace operations, a CO₂ flow meter and pressure control system and a display panel providing information on the status of the furnace and sample. An apparatus (RDC-141) was shown previously in figure 2.

2.1 Tube Reactor

The tube reactor consists of two quartz tubes and a cover which are assembled as shown in Figure 2. The flow of CO₂ gas into the reactor tube is via the gas inlet and exterior to the inner tube, allowing the gas to be preheated before flowing upwards through the fritted disc and petroleum coke sample, and out the gas outlet in the cover. The fritted disc has a pore size of 250 - 500 μm and the tip of the protection tube containing the thermocouple lies 5mm underneath it.



2.2 Thermocouple

A chromel-alumel K-type thermocouple having a precision better than $\pm 0.375\%$ according to the DIN 43710 standard is used to measure the temperature. It should have a diameter of 2 mm and a length of 200mm.

Figure 2 Tube Reactor Assembly

2.3 Furnace

The furnace should ensure a good vertical temperature distribution and a heating time from 20 to 1000°C of less than one hour. To meet these requirements necessitates constructing a furnace with kanthal heating elements having vacuum

formed, ceramic fibre insulation.

The dimensions of the furnace, including a holder for the tube reactor assembly are



Figure 3 Furnace Dimensions and Characteristics shown in figure 3.

2.4 Control Box

The front panel of the control box consists of:

- a "MAIN SWITCH" and associated lamp (light emitting diode or LED).
- an "ON" button for starting the furnace.
- a valve for regulating the inlet pressure to 2 bars.
- a pressure gauge having a full-scale of 10 bars (145.0 psi).
- a rotameter with a calibrated scale for CO₂ gas (at p = 1 atm) having a full-scale of 60l/h and a precision better than $\pm 2\%$.
- a "SAMPLE IN" switch for starting the test cycle immediately after introduction of the sample
- 4 lamps giving information on the status of the analytical cycle (see section # 4) labelled "FURNACE ON", "CO₂ ON", "SAMPLE IN", "SAMPLE OUT".

The side panel of the control box consists of:

- Power line filter with IEC Inlets and 2 fuses (6.3 A). The electrical connection (cable) is delivered with the unit.
- the CO₂ connection.
- a calibration dial that controls how long the sample remains at 1000°C.

2.5 Temperature Control Unit

A two point temperature DPID controller with set value adjuster (adjustment error <0.5%) and digital temperature display is used to control the temperature. A microprocessor inside the control box controls the heating/cooling cycle, the on/off switching of the gas flow and the illumination of the status lamps.

Section 3.

SAFETY INSTRUCTIONS

3. SAFETY INSTRUCTIONS

3.1 General

Warnings and safety instructions regarding the use of the equipment are provided throughout this manual. The most important of these are summarised below (#3.2-3.4) with more detailed information being given in the appropriate section relating to installation (#4), operation (#5) and maintenance (#6). Two types of warning are used in these sections to identify the potential risks or hazards involved in the installation, operation and maintenance of the apparatus

Warnings where there is an immediate hazard which will result in severe personal injury or death are indicated by:



Warnings where there is a hazard or unsafe practice which could result in personal injury or property damage are indicated by:



3.2 Safety Regarding Installation

It is the **owner's responsibility** to select a proper location for the RDC-141 apparatus. The installation should be undertaken **only** in compliance with all applicable state and local fire and building codes.

WARNING

**TO REDUCE THE RISK OF
PERSONAL INJURY OR PROPERTY DAMAGE:**

- a. Install equipment in a **WELL VENTILATED** area or **FUMEHOOD**.
- b. **DO NOT** install closer than 25 centimeters (10 inches) to any wall or door.
- c. Use a **QUALIFIED ELECTRICIAN** for wiring.
- d. Equipment must be properly **GROUNDED**

3.3 Safety Regarding Operation

Although the RDC-141 apparatus is operated and controlled electronically, the user must nevertheless perform several manual tasks.

WARNING

**TO REDUCE THE RISK OF
PERSONAL INJURY OR PROPERTY DAMAGE:**

- a. Keep hands and arms **CLEAR** of furnace surface.
- b. **ALWAYS** wear **PROTECTIVE GLOVES** when handling samples.
- c. Ensure gas outlet remains unblocked.
- d. Measure **ONLY** carbon samples.

3.4 Safety Regarding Maintenance

It is the **owner's responsibility** to ensure that only trained or appropriately qualified

Rev. 02/2000

RDC-141, User's Manual

personnel undertake any form of maintenance on the

<p style="text-align: center;"><i>WARNING</i></p> <p style="text-align: center;">TO REDUCE THE RISK OF PERSONAL INJURY OR PROPERTY DAMAGE:</p>
a. ALWAYS UNPLUG equipment BEFORE attempting repairs.
b. WAIT until furnace is completely COOLED before interior surfaces.

RDC-141 apparatus.

3.5 Warning Labels on the RDC-141 Apparatus

The warning labels that appear on the apparatus and their location are depicted below.

It is the **owner's responsibility** to ensure that these warning labels remain in place and can be read for the lifetime of the equipment. Replacement warning labels can be obtained from R&D Carbon Ltd. at the address or contact numbers given at the beginning of this manual.

Only warning labels against electrical hazards are displayed on the RDC-141 apparatus. These consist of black markings on a yellow background. Two such labels are attached to the control box - one on the removable back grill and the other inside the control box on the reverse side of the front panel.

Section 4.

INSTALLATION

4. INSTALLATION

4.1 Installation Site

It is the **owner's responsibility** to select a proper location for the RDC-141 apparatus. The installation should be undertaken **only** in compliance with all applicable state and local fire and building codes. As each furnace has a power rating of 2 kW (1.9 Btu/sec) it is advisable to keep the apparatus a reasonable distance from any building structure (wall or door) that is **not** heat-resistant.

CAUTION

TO AVOID A FIRE HAZARD

Do not install closer than 25 centimetres (10 inches) to any wall or door.

As one of the gaseous products of the reaction may be carbon monoxide the apparatus must be placed in a well ventilated location. This is particularly important if the site is a small room having no windows or skylight and an entrance that can be closed (such as a door). Each sample has a typical weight of 5 g and in a bad case up to 15 % of this initial weight may be consumed by reaction prior to ignition. From equation 2, it can be calculated that a 5 g carbon sample may yield up to 3.4 g carbon monoxide. Consequently, if a test is run eight times a day using such samples, the CO produced in a 24 hour period is 28 g. The Threshold Limit Value (TLV) for carbon monoxide is given in the CRC Handbook of Chemistry and Physics (p. D-125) as 50 ppm or 55 mg/m³. Therefore for a 100 m³ (3530 ft³) "closed" room, where CO loss is negligible, the TLV will be reached in less than two hours.

DANGER

TO AVOID EXPOSURE TO EXCESSIVE LEVELS OF CARBON MONOXIDE GAS

The RDC-141 apparatus must be installed in a well ventilated room or fumehood where fresh air is continuously being recycled.

4.2 Unpacking

The RDC-141 apparatus will be sent in a wooden crate that rests on "feet" so allowing transportation by forklift and also ensuring that it is not delivered upside down. The top cover and a side panel can be unscrewed to allow access to the apparatus. Before removal from the crate, all support panels (used to keep the apparatus rigidly in place during shipment) should be taken out and the plastic covering pulled off. The apparatus can be lifted out manually or with a crane and should be supported at the base. The total weight of the apparatus is 45 kg (= 100lb).

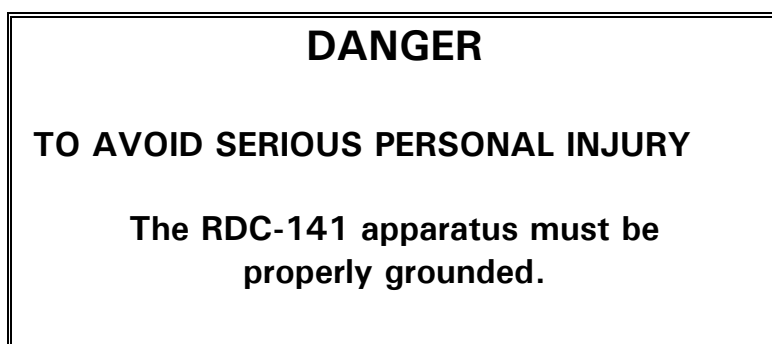
4.3 Assembly Instructions

The RDC-141 apparatus has been completely assembled, checked and found to be operating correctly prior to shipment. A visual inspection should be carried out for any obvious signs of damage that may have occurred during transportation. This should also include a check that the thermocouples are still in place and that the two electrical cables are still plugged into the furnace (red to red, black to black).

The quartz reactor tubes and any additional spare parts that may have been ordered will be packed separately in the same crate. These should be checked with the packing list to ensure that all specified items have been delivered.

Once located in the appropriate site (see #3.2) the gas and electrical connections can be made at the bottom left corner of the side panel on the control box.

The electrical wiring of the apparatus to the mains power supply should be carried out **only** by a qualified electrician. The apparatus can be grounded by connecting the earth wire of the existing cable to the appropriate pin on the plug to be used. (This plug is **not** supplied with the equipment).



To insert the assembly carry out the following steps:

- (1) Insert the external tube carefully and fix it with the clamping device.
- (2) Tilt the apparatus backward and put the thermocouple completely into the protection tube by passing it through the hole in the bottom panel.
- (3) Insert the reaction tube into the external tube.

RDC-141, User's Manual

- (4) **Adjust the height of the thermocouple so the tip is 5mm from the bottom of the fritted disc in the reaction tube.**
- (5) **Fix the thermocouple to the frame.**

The CO₂ gas should be of the following gas quality:

CO₂ better than 99.5 %

N₂ + Ar < 0.5 %

H₂O < 150 mg/Nm³, 9.4 x 10⁻⁶ lb/Nft³

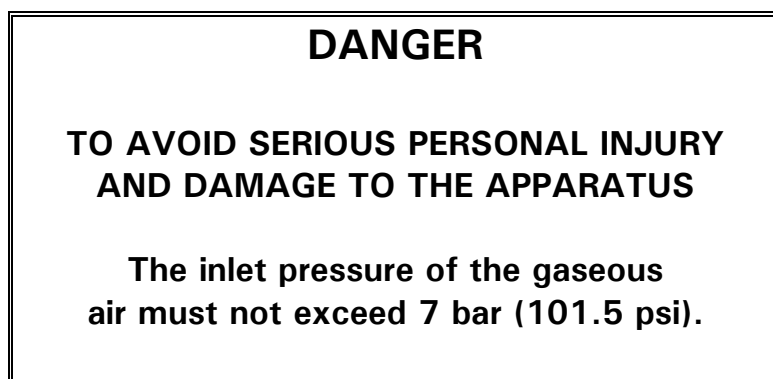
The inlet pressure should not exceed seven (7) bar (101.5 psi) and appropriate tubing should be used from the gas supply line to the apparatus. Where plastic tubing is to be used, the following specifications apply:

external diameter: 6 mm (0.236 inch)

internal diameter: 4 mm (0.157 inch)

pressure/temperature: to withstand 10 bar (145.0 psi) minimum at a temperature of 80°C (176 °F).

The apparatus is designed to withstand a maximum pressure of 10 bar (145.0 psi) and any pressures greater than this may result in damage and personal injury (for example, bursting of the pressure gauge).



4.4 Pre-operation Inspection

Prior to operating the RDC-141 apparatus a series of checks should be implemented.

- (1) Turn on the main switch on the front panel.
- (2) Set the calibration dial on the side of the control box to 100 minutes.
- (3) Set the temperature controller on the front panel to 1000°C.
- (4) Insert the empty inner quartz tube and fix the cover with the clamp.
- (5) Activate the furnace and the gas by pushing the "FURNACE ON" button. The lamps "Furnace on" "CO₂ on" "Sample out" are alight.
- (6) Regulate the gas pressure to 2 bar by turning the valve on the control panel directly below the pressure gauge.

Rev. 02/2000

RDC-141, User's Manual

- (7) Regulate the gas flow rate to 50 L/h by turning the valve on the rotameter.
- (8) When the furnace temperature has stabilised at 1000°C, an alarm will sound.
- (9) Calibrate the apparatus as outlined in #4.5.

4.5 Calibration

The calibration procedure should be performed once a week and after any maintenance of the apparatus (reactor tube or thermocouple replacement etc).

- (1) Turn on the main switch on the front panel.
- (2) Set the calibration dial on the side of the control box to 100 minutes.
- (3) Set the temperature controller on the front panel to 1000°C.
- (4) Insert the empty inner quartz tube and fix the cover with the clamp.
- (5) Activate the furnace and the gas by pushing the "FURNACE ON" button. The lamps "Furnace on" "CO₂ on" "Sample out" are alight.
- (6) Regulate the gas pressure to 2 bar by turning the valve on the control panel directly below the pressure gauge.
- (7) Regulate the gas flow rate to 50 NL/h by turning the valve on the rotameter.
- (8) When the furnace temperature has stabilised at 1000°C, an alarm will sound.
- (9) After the standby temperature is reached, the weighed standard sample (5 ± 0.001g) can be placed in the inner quartz tube and the cover refixed with the clamp. The calibration standard is provided by R&D Carbon Ltd. who have carried out a round robin involving at 10 apparatus measuring at least one coke sample so that the average value can be statistically guaranteed.
- (10) Press the "SAMPLE IN" button to start the measurement cycle. The lamps "Furnace on" "CO₂ on" "Sample in" are alight.
- (11) After 100 minutes the furnace will switch off automatically and 45 minutes later an alarm will sound.
- (12) Take the internal reaction tube out and place it in the holder to cool for about 10 minutes.
- (13) Reset the furnace and the gas by pushing the "FURNACE ON" button. None of the lamps will be alighted.
- (14) Weigh the remaining sample to a precision of ±0.001 g.
- (15) Calculate the reactivity in % weight loss as follows:

$$\text{func R sub \{CO sub 2\} \sim = \sim \{initial weight \sim - \sim final weight\} over \{initial weight\} \sim CDOT \sim 100 over 1 \%}$$

- (16) Set the new calculated time on the calibration dial according to the equation:

RDC-141, User's Manual

$$\text{TIME} \sim = \sim \left\{ \frac{R_{\text{CO}_2} \sim \text{Standard value}}{R_{\text{CO}_2} \sim \text{Measured Value}} \right\} \sim \text{CDOT} \sim 100$$

- (17) Check the calibration with a new standard sample.
- (18) The apparatus is now ready for routine measurement.

Section 5.

OPERATION

5. OPERATION

It is the **owner's responsibility** to ensure that the operator is properly trained and instructed on how to use the RDC-141 apparatus.

5.1 Principle

A sample of petroleum coke is placed in a reactor tube and heated in an atmosphere of CO₂, for approximately 100 minutes at a temperature of 1000°C. The weight loss due to the chemical reaction in equation 1 (see section 1) is then measured.

5.2 Sampling and Sample Size

A representative sample of calcined petroleum coke is taken from the whole in accordance with ISO Doc. 6375. This is divided into three fractions by sieving according to the procedure ISO Doc. 2325:

I	> 1.4 mm
IIa	1 - 1.4 mm
III	< 1.4 mm

Fraction I is crushed so that most of the fraction

IIb	1 - 1.4 mm
-----	------------

is obtained after sieving. Fractions IIa and IIb are then thoroughly mixed, and the mixture dried at $120 \pm 2^\circ\text{C}$ to constant weight.

Many granular materials are coated with oil, for example to control dust formation during processing. If this is the case, the sample material must be rinsed with Methylene Chloride before drying to remove the oil according to the procedure outlined in ISO Doc. 8723.

$5 \pm 0.001\text{g}$ of sample are weighed for the test measurement.

5.3 Procedure

Before measuring the first sample, the pre-operation inspection described in the installation section (#4.4) and the calibration procedure (#4.5) should be undertaken. Once this has been completed the procedure described below can be fol-

lowed.

- (1) Turn on the main switch on the front panel.
- (2) Set the temperature controller on the front panel to 1000°C.
- (3) Insert the empty inner quartz tube and fix the cover with the clamp.
- (4) Activate the furnace and the gas by pushing the "FURNACE ON" button.
- (5) Regulate the gas pressure to 2 bar by turning the valve on the control panel directly below the pressure gauge.
- (6) Regulate the gas flow rate to 50 NI/h by turning the valve on the rotameter.
- (7) When the furnace temperature has stabilised at 1000°C, an alarm will sound.
- (8) After the standby temperature is reached, the weighed sample (5 ± 0.001 g) can be placed in the inner quartz tube and the cover refixed with the clamp.
- (6) Press the "SAMPLE IN" button to start the measurement cycle.
- (7) After 100 minutes the furnace will switch off automatically and 45 minutes later an alarm will sound.
- (8) Take the internal reaction tube out and place it in the holder to cool for about 10 minutes.
- (9) Reset the furnace and the gas by pushing the "FURNACE ON" button.
- (10) Weigh the remaining sample to a precision of ± 0.001 g.
- (11) Calculate the reactivity in % weight loss as follows:

$$\text{func R sub \{CO sub 2\} } \sim = \sim \{ \text{initial weight } \sim - \sim \text{final weight} \} \text{ over } \{ \text{initial weight} \} \\ \sim \text{CDOT } \sim 100 \text{ over } 1 \%$$

Section 6.

MAINTENANCE

6. MAINTENANCE

6.1 General

A list of spare parts is given in appendix B and this comprises those items that RDC experience has shown will generally need to be replaced at some point during the lifetime of the apparatus. A complete list of all individual parts is **not** given here. If information is required for a specific part or problem that is not outlined below, direct contact should be made with R&D Carbon Ltd. at the address or contact numbers given in the beginning of this manual.

Any maintenance on the RDC-141 apparatus should only be undertaken after cooling of the furnace(s) and after disconnecting the electrical plug to the mains power supply. Only qualified or trained personnel should attempt to carry out such maintenance work.

DANGER

TO AVOID SERIOUS PERSONAL INJURY

Before attempting any maintenance work
on the RDC-141 apparatus :

- (1) ensure only qualified or trained personnel carry out the work
- (2) disconnect the mains power supply
- (3) ensure the furnaces have cooled

6.2 Replacing the Furnace

To replace a complete furnace unit, carry out the following:

- (1) Turn off the "MAIN SWITCH".
- (2) **DISCONNECT THE APPARATUS FROM THE MAINS POWER SUPPLY.**
- (3) Disconnect the two electrical cables plugged into the furnace.
- (4) Disconnect the gas cable above the furnace.
- (5) Release the clamp holding the sample assembly in place.
- (6) Lift the sample assembly out of the furnace.
- (7) Unplug the thermocouple connecting cable leading to the microprocessor and remove the thermocouple.
- (8) There are three screws holding the furnace onto the support frame behind the furnace. Undo these screws and remove the furnace.
- (9) Attach the replacement furnace to the support frame by means of the three

screws.

- (10) Remount the sample assembly.
- (11) Reinsert the thermocouple and control the height between the top of the thermocouple and the fritted disc to 5mm.(7)

The gas cable and furnace cables can now be reconnected; the mains power reconnected and the "MAIN SWITCH" turned on. The replacement furnace should now be tested by following the pre-operation inspection described in the installation section (#4.4).

6.3 Replacing the Heating Element

To replace a heating element, carry out the following:

- (1) Turn off the "MAIN SWITCH".
- (2) **DISCONNECT THE APPARATUS FROM THE MAINS POWER SUPPLY.**
- (3) Disconnect the two electrical cables plugged into the furnace.
- (4) Disconnect the gas cable above the furnace.
- (5) Release the clamp holding the sample assembly in place and lift the sample assembly out of the furnace.
- (6) Unplug the thermocouple connecting cable leading to the microprocessor and remove the thermocouple.
- (7) Remove the furnace cover by unscrewing the three screws on top of the furnace.
- (8) Disconnect the two cables from the heating element endpieces.
- (9) The original heating element can now be removed from the external casing of the furnace unit and the replacement installed.
- (10) Reconnect the two cables to the heating element endpieces and tighten well to ensure good electrical contact.
- (11) Remount the sample assembly.
- (12) Reinsert the thermocouple and control the height between the top of the thermocouple and the fritted disc to 5mm.(7)

The gas cable and electrical cables can now be reconnected; the furnace cover replaced, the sample assembly remounted, the mains power reconnected and the "MAIN SWITCH" turned on. The replacement furnace can now be tested by following the pre-operation inspection described in the installation section (#4.4).

6.4 Replacing the Temperature Controller

To replace a temperature controller or remove it for inspection, carry out the following:

- (1) Turn off the "MAIN SWITCH".
- (2) **DISCONNECT THE APPARATUS FROM THE MAINS POWER SUPPLY.**
- (3) Remove the back cover of the control box by unscrewing the four screws.

- (4) Disconnect all wires in the back of the temperature controller, noting carefully their position for later reconnection.
- (5) Unscrew the four screws holding the temperature controller against the front panel. These can now be slid out of their grooves and removed. **PAY ATTENTION TO SUPPORT THE TEMPERATURE CONTROLLER WHILE DOING THIS.**
- (6) The temperature controller can now be pulled out, from behind, through the back of the control box.
- (7) The replacement temperature controller can now be installed by carrying out the above instructions in reverse order.

6.5 Replacing the Thermocouple

A thermocouple can be simply replaced by unplugging the connecting cable that leads to the microprocessor; removing the defective thermocouple; inserting the replacement thermocouple and reconnecting the controller cable. The top clamp which holds the glastubes is fixed first and then the thermocouple is mounted to be at the upper limit.

6.6 Replacing the External Reaction Tube

To replace the external reactor tube carry out the following procedure:

- (1) Turn off the "MAIN SWITCH"
- (2) **DISCONNECT THE APPARATUS FROM THE MAINS POWER SUPPLY.**
- (3) Disconnect the two electrical cables plugged into the furnace.
- (4) Disconnect the gas cable above the furnace.
- (5) Release the clamp holding the sample assembly in place.
- (6) Lift the sample assembly out of the furnace.
- (7) Unplug the thermocouple connecting cable leading to the microprocessor and remove the thermocouple.
- (8) Remount the sample assembly with the new external reactor tube and center it.
- (9) Reinsert the thermocouple and control the height between the top of the thermocouple and the fritted disc to 5 mm.

The gas cable and furnace cables can now be reconnected; the mains power re-connected and the "MAIN SWITCH" turned on.

The replacement furnace should now be tested by following the pre-operation inspection described in the installation section (#4.4).

6.7 Replacing the Triac

The triac inside the control box mounted on the heat-sink controls the delivery of current (power) to the furnace by means of the controller. It is located on the secondary side of the transformer and therefore operates at about 20 amperes (860 VA/240 V). To replace a triac that has failed, carry out the following:

- (1) Turn off the "MAIN SWITCH".
- (2) **DISCONNECT THE APPARATUS FROM THE MAINS POWER SUPPLY.**
- (3) Remove the back cover of the control box by unscrewing the four screws.
- (4) Observe the position of the triac at the side of the box mounted on the heatsink. Loosen the triac by slightly unscrewing the two screws.
- (5) Take the triac out of the control box and remove the three connecting wires, noting their exact position. Reconnect the replacement triac with these wires in the same place.

The triac can now be attached to the heatsink by means of the two screws; the cover screwed back in place; the mains power reconnected and the "MAIN SWITCH" turned on. The triac is working if the furnace heats up.

6.8 Replacing the Control Unit for Gas & Furnace Operation

To replace this Unit, carry out the following:

- (1) Turn off the "MAIN SWITCH".
- (2) **DISCONNECT THE APPARATUS FROM THE MAINS POWER SUPPLY.**
- (3) Remove the back cover of the control box by unscrewing the four screws.
- (4) Disconnect all wires in the back of the unit, noting carefully their position for later reconnection.
- (5) Unscrew the four long support screws holding the unit against the left side of the apparatus.
- (6) The unit can now be removed, from behind, through the back of the control box.
- (7) The replacement unit can now be installed by carrying out the above instructions in reverse order.

6.9 Replacing the Transformer

- (1) Turn off the "MAIN SWITCH".
- (2) **DISCONNECT THE APPARATUS FROM THE MAINS POWER SUPPLY.**
- (3) Remove the grill at the back of the control box.
- (4) Disconnect all wires connected to the transformer, noting carefully their position for later reconnection.
- (5) The transformer is fixed with two screws to the base of the control box. Remove these screws and lift out the transformer, through the back of the control box.
- (6) The replacement transformer can now be installed by carrying out the above instructions in reverse order.

6.10 Periodical Control

- (1) Check that the glassware is clean and not damaged.
ie: it must not be bent or cracked.
- (2) Check that the gas can flow through the quartz bed freely.
- (3) Check the symmetry: The glass must be centred in the furnace.
- (4) Check the top clamp for any freeplay or clearance.
- (5) Check that the thermocouple is adjusted to the correct height:
First adjust the top clamp before adjusting the thermocouple at the bottom.
- (6) Check the top cover that the exhaust hole is not blocked.
- (7) Run the standard twice to check the calibration of the equipment.
- (8) If glass particles are falling off when the sample is removed to be weighed the

RDC-141, User's Manual

- glass must be replaced.
- (9) Check that the recommended spare parts are complete.

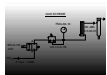
APPENDICES

Appendix A. Technical Drawings

Appendix B. Spare Parts List

APPENDIX A. Technical Drawings

Technical drawings include the wiring diagram for the electrical circuit and the gas flow diagram for the CO₂. These are shown on the following pages.



<p>RDC-141 COKE AIR REACTIVITY</p>
--

<p>RDC-141 COKE AIR REACTIVITY</p>
--

APPENDIX B. Spare Parts List

SPARE PARTS	DESIGNATION
141-01	Cover
141-02	Internal Reaction Tube

RDC-141, User's Manual

141-03	External Quartz Tube	
141-04	Clamp for Cover	
141-05	Thermocouple	NiCrNi
141-06	Temperature Controller	KS92
141-07	Heating Element	15 V / 0.86 kW
141-08	Control Unit for Gas & Furnace Operation	
141-09	Resistor	3♣ / 225 W
141-10	Transformer	UP 220/US 15 V
141-11	Flowmeter	DK 48N
141-12	Air Solenoid Valve	MDH-2-2,2-QS-6-24VDC
141-13	Air Pressure Valve	LR-1/4"-S
141-14	Manometer	FMA-63-10
141-15	Clamp, cornered Jaws	
141-16	Bosshead	

APPENDIX C. ISO Standard Methods for Coke Sampling

- ISO 6375 Carbonaceous materials for the production of aluminium - Cokes for electrodes - Sampling.
- ISO 2325 Coke - Size analysis.
- ISO 8723 Carbonaceous materials for the production of aluminium - Calcined coke - Determination of oil content - Method by solvent extraction.